STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS DIVISION
SUITE 1800, JAMES K. POLK BUILDING
505 DEADERICK STREET
NASHVILLE, TENNESSEE 37243-1402
(615) 253-1122

CLAY BRIGHT
COMMISSIONER

BILL LEE
GOVERNOR

TO: Will Reid, Assistant Chief Engineer of Operations

FROM: Brad Freeze, Director of Traffic Operations

SUBJECT: **Proprietary Item Request and Justification**
ITS SmartWay Local Area Networks
Statewide

ITS SmartWay Local Area Networks: The Tennessee Department of Transportation (TDOT) is providing a certification specifying the following devices to be used on the Intelligent Transportation Systems (ITS) SmartWay Local Area Networks. These devices (or its equivalent) can be used on projects throughout the state of Tennessee (on ITS SmartWay networks) over the next three years using federal funds. The network devices are listed as following:

- Aggregation Services Routers: Cisco 1000 Series
- Connected Grid Routers: Cisco 1000 and 2000 Series
- Industrial Integrated Services Routers: Cisco 800 Series
- Integrated Services Routers: Cisco 4000 Series
- Integrated Services Rugged Router: Cisco IR1101
- Enterprise Switches: Cisco Catalyst 9200 and 9300 Series
- Network Switches: Cisco Industrial Ethernet 3200, 3300, 3400, 4000, 4010, and 5000 Series
- Industrial Compute Gateway: Cisco IC3000

Using above Cisco Routers and Switches is necessary for the following reasons:

1. Compatibility with currently installed core network equipment for the advanced operation and security of the ITS networks and devices.
2. Synchronization capabilities for spare parts inventory of the network switching systems and software applications to enable and support connectivity, configuration, and network management.
3. Interoperability with local network equipment and software.
4. Executing container based applications on edge devices to enable distributed computing across the network.
5. Covered by the in-house knowledge and certifications acquired by the TMC support personnel.

This selection is essential for the synchronization of existing ITS infrastructure equipment to ensure enhanced, secure, and continuous performance of the network. Such performance is dependent on the compatibility of the supporting equipment and software and the availability of spare parts inventory.

I, Brad Freeze, Director of the Traffic Operations Division of the Tennessee Department of Transportation, do hereby certify that in accordance with the requirements of 23 CFR 635.411(a) (2) that the patented or proprietary items listed above are essential for the synchronization of existing facilities.

Assistant Chief Engineer of Operations

9/30/19
Date

SECTION 15
LOCAL AREA NETWORK

15.1 Description

15.1.1 *Overview*

1. Segments of the project deployment will have multiple ITS field devices concentrated via agency owned fiber optic network. The Design-Builder will furnish and install new L2 Field Ethernet Switches at these locations identified in the Plans. The Design-Builder shall integrate the L2 Field Ethernet Switches with the Ethernet bridge devices.

15.1.2 *Virtual Local Area Network (VLANS)*

1. For the L2 Field Ethernet Switches installed in the field, VLANs shall be developed to group devices by type. Where utilized, the management VLAN will be logically separate from all other VLANs to ensure manageability during network events and to provide additional security.

2. Common/consistent ports shall be used for the edge devices for common devices. Up to two ports shall be reserved for future device classes. One port shall be reserved for network connection by a laptop computer at the equipment cabinet. This shall be the only port configured with access to the management VLAN.

15.1.3 *Requirements Definition Document*

1. Prior to commencing work, the Design-Builder shall develop a Requirements Definition Document (RDD) that will form the basis for the overall network architecture and design.

It is expected that the Design-Builder will work closely with TDOT IT to define the network. The document will contain:

a. Complete description of the proposed implementation of the access, distribution and core layers for the ITS network as described in the Plans and these Project Special Provisions.

b. Development of an IP Design Scheme with ranges assigned to each node to be integrated by the Design-Builder using guidance from TDOT (e.g. address ranges, geographic distribution, standards for addresses within each cabinet).

c. Proposed IP subnet definition and addressing including any and all masks

d. Proposed IP multicast configuration including multicast routing (i.e., PIM sparse or dense) and Rendezvous Point (RP) designation as necessary

e. Proposed recommendations for failover and redundancy including network device power, supervisor cards, and network ports

f. Proposed configuration and guidelines for L3 routing (OSPF, VRRP, EIGRP, RIP, etc.);

g. Proposed configuration and guidelines for Virtual LAN assignments including management VLANs, device VLANs and routing VLANs; and

h. Proposed configuration and guidelines for L2 broadcast storm prevention, loop prevention and fault tolerance mechanisms. (Spanning Tree diagram with designated, blocking and forwarding ports indicated. Root bridge and backup root bridge must also be specified.) Incorporation of Multiple Spanning Tree Protocol.

i. Proposed configuration and guidelines to mitigate common security threats such as denial of service, man in the middle, MAC/IP spoofing and brute force dictionary attacks.

j. Proposed configuration and guidelines for 802.1p Class of Service (COS) queue assignments

k. Proposed configuration and guidelines for specific port assignments on each of the L2 and Ethernet bridge device.

2. The Engineer will provide the Design-Builder with an IP address range or ranges from which the Design-Builder will develop the IP address scheme. The RDD shall be prepared by a qualified networking professional (minimum CCNA or a manufacturer-approved equivalent based on the approved hardware vendor) and will be approved by the Engineer. The Qualified network professional will be present during the installation and testing of the local area network as well as during system testing

15.2 Materials

15.2.1 *General*

1. Furnish equipment for the LAN that complies with applicable IEEE 802 standards. Furnish Ethernet LAN switches that are fully compatible and interoperable with the network monitoring software, the existing network architecture and configuration, and the existing firewall and switch at the TMCs.

2. Furnish Ethernet Switches that comply with the following electrical safety requirements: UL60950 or CSA C22.2 No. 60950 (safety requirements for IT equipment) and FCC Part15 Class A for EMI emissions.

15.2.2 *Network Switch (Type A) (L2 Field Ethernet Switch)*

1. L2 Field Switches will be placed in locations shown on the Plans. L2 Field Switches fabricated for use in traffic signal controller cabinets shall meet or exceed NEMA TS- 2 requirements for temperature, shock, humidity, and vibration.

2. Furnish L2 Field Ethernet Switches that have the option for din rail mounting as well as rack mounting.

3. Furnish Field Ethernet switches with internal Power Supply meeting the following power supply requirements:

    a. 85 to 264 VAC (50/60Hz)/ 88 to 300VDC.
    b. Power supply shall have two stage isolation accomplished via two transformers: first steps down from primary AC/DC to 48VDC; the second steps down from 48VDC to the final DC voltage required by the switch.

    c. A power cord of not less than 5 feet in length shall be supplied

4. Furnish Field Ethernet Switches that weigh no more than 15 lbs and are no more than 250 cubic inches in volume.

5. Furnish field Ethernet switches with the following minimum characteristics and features:

    a. Minimum of Eight (8) 10BASE-T/100BASE-TX ports

    b. Minimum of two (2) 1000 BaseX Optical uplink ports that utilize SFP plugs

c. Furnish SFP modules rated to service the Field Ethernet to Field Ethernet optical uplinks and Field Ethernet to Gig-E Hub Uplink rated for optical attenuation required to service the link. Use SFP modules that are LX or ZX and are matched and compatible with the SFP module it is mated with. Furnish attenuators if required to service link without saturating receiving optics.

d. Furnish SFP modules rated for use with the optical cable furnished under this project

e. Furnish SFP modules with LC connector or other connector approved by the Engineer

f. Furnish fiber jumper cables with appropriate connectors to connect with switch and adjacent drop cable connectors and/or other switches.

g. SFP modules shall be considered incidental to the field Ethernet switch

h. Management console port

i. 10/100BaseTX ports:

    i. RJ45 connectors

    ii. Cable type: Category 6, unshielded twisted pair (CAT 6 UTP)

    iii. Auto-negotiation support (10/100Mbps)

    iv. Auto MDIX crossover capability

    v. Full Duplex operation (IEEE 802.3x)

    vi. SPD (Surge Protective Device) between Line +/-, Line +/ground, and Line –ground to protect the circuitry

j. Networking Requirements

    i. The switch shall support automatic address learning of up to 8000 MAC addresses

    ii. The switch shall support the following advanced L2 functions:

        - IEEE 802.1Q VLAN, with support for up to 1000 VLANs
        - IEEE 802.1p priority queuing
        - IEEE 802.1w rapid spanning tree

- IEEE 802.1s multiple spanning tree
- IEEE802.3AD link aggregation
- IEEE 802.3x flow control
- IGMPv2 with 256 IGMP groups
- Port Rate Limiting
- Configuration via test file which can be modified through standard text editor
- Forwarding/filtering rate shall be 14,880 packets per second (PPS) for 10Mps,148,800 for 100Mps, 1,488,000 for 1000Mps
- DHCP Option 82

iii. Network Management Functionality Requirements

- Shall be interoperable with the existing network infrastructure (Cisco core multi-layer switches, distribution multilayer switches, firewalls, and routers)
- Shall have the ability to run container applications
- SNMPv2 and SNMPv3
- RMON
- GVRP, or VTP
- Port Mirroring
- 802.1x port security
- Radius Server and TACACS+ Server
- SSL – Secure Socket Layer
- SSH – Secure Shell
- TFTP
- Network Time Protocol (NTPv3)
- Simple Network Time Protocol (SNTPv3)

- Management via web only if HTTPS SSL and SSH

15.2.3 *Ethernet Bridge*

1. The field bridge shall provide bridging Ethernet across one or more T-1 leased lines through Multilink Point-Point Protocol (MLPPP). The functions of the field bridge shall be to:

    a. Provide physical and link layer protocol compatibility for bridging

    b. Support virtual extension and integration of field CCTV cameras with the TMC Ethernet LAN via one or more T-1 communication links. The field bridge shall provide multilink bonding of multiple T-1 links to form a single aggregate data channel between the wireless Ethernet radio system and the TMC router

    c. Combine all Ethernet messages into a common Ethernet at the physical, link, and network level

    d. Incorporate TCP/IP, supporting network bridging

    e. Buffer data as required to accommodate input/output data rates without loss of data and without causing transfer delays

    f. Transparently manage lower level protocols

    g. Accommodate full-duplex data transmissions on all T-1 interfaces

    h. Conduct built-in test and report failures via alarms and indicators

2. The field bridge shall be required to bridge between Ethernet and T-1 protocols. The Ethernet bridges shall provide an Ethernet LAN virtually extended via one or more T-1s from TMC- to-CCTV demarcation and vice versa using telephone service provider T-1 circuits (MLPPP).

3. Ethernet bridges installed at each communication hub/concentrator shall include a minimum of two T-1 interfaces (expandable to four T-1s), and shall also include at least three 10/100Mbps full-duplex auto-sensing switched Ethernet ports with auto-negotiation capabilities. Each bridge shall be equipped with internal CSU/DSUs for direct termination of the telephone service provider T-1 circuits. To prevent the loss of data during extended power outages, Ethernet bridge configuration settings, commands, and programming shall be stored in non-volatile memory, and forwarded to the network according to pre-defined criteria.

4. The Design-Builder shall assure that compatible bridging and network management protocols are used in all Ethernet bridges. The Ethernet bridges shall sustain throughput over the aggregate T-1 links of at least 1.5 Mbps for each T-1 link. Field bridges shall be fully communications- compatible with the video encoders and wireless Ethernet radios supplied per these Special Provisions.

5. The Ethernet bridge chassis shall be provided with slides that allow the electronic drawer to be removed from the rack and be locked into a maintenance position. The slides also shall allow the drawer to be completely removed from the field cabinet by activating mechanical unlocking devices. The chassis shall be constructed from non-corrosive materials. The front panel shall be of ergonomic design for ease of use and include indicators that display Power, Self-Test, and Alarm status.

6. The TMC Ethernet Bridge will include all requirements of the Multi-T1 Ethernet Bridge devices except shall provide instead a T-3 interface.

7. All switches, indicators, and connectors shall be clearly and permanently marked as to identity and function and all removable components shall be identified by appropriate markings. All printed circuit boards shall have permanent markings, including a part number and functional name. Each removable module shall, as a minimum, include a permanently attached (e.g., stamped, etched, etc.) part number. Each removable module shall also include a permanently attached serial number. All component identifications shall correctly correspond to schematics, parts lists, and written narratives included in maintenance manuals.

8. All software required to operate and update network configuration/bridging, and to maintain the field Ethernet bridge shall be provided with the equipment. If the field Ethernet bridge requires loadable software for either operations or maintenance, the software shall be provided on a magnetic media compatible with the delivered equipment.

15.2.4 *Electrical Requirements*

Each Ethernet bridge shall operate subject to the following electrical power specifications:

1. Input Voltage: 115 VAC +/-10% at 60Hz

2. The Ethernet bridges shall include a power-on switch and a power status indicator. Any required power conversion shall be contained within the bridge, the router chassis, or facilitated by a power adapter provided as an integral part of the bridge power-interconnect cable. The Ethernet bridge power input circuitry shall be designed to protect the electronics from damage by a power surge or an under voltage condition. The Ethernet bridges shall automatically recover from an over or under voltage condition when the prime power has returned to values defined by this specification, and in turn re-acquire signal. The Ethernet bridges shall include surge protection designed to react within one second of the occurrence of over voltage conditions and shall provide protection for the duration of the disturbance.

3. Where surge protection is not internally provided, the Design-Builder may provide external surge protection. The input power cable shall be no less than 5'.

15.2.5 *Physical and Environmental Requirements*

1. Each Ethernet bridge shall be rack or shelf mountable in a 19" EIA-310 style equipment rack, and shall not exceed 2 rack units in height (3.5") and shall fit sufficiently within the depth of the field cabinet. These dimensions shall be inclusive of any required external devices including, but not limited to power supplies. Each Ethernet bridge shall be industrially hardened for application in a non-environmentally controlled cabinet.

2. The field Ethernet bridge shall operate within temperatures ranging from -4°F TO 149°F (- 20°C to 65°C) with a relative humidity between 0% and 90%.

15.2.6 *Network Management and Remote Monitoring Software (NMS)*

1. TDOT currently uses an existing NMS platform to monitor the field network. The existing platform is SNMPc by CastleRock. Network Configuration Management and Network Performance Monitoring modules are monitored using Orion by SolarWinds.

2. Design-Builder shall coordinate with TDOT IT to update the NMS with the Design-Builder's proposed changes.

15.3 Installation Requirements

15.2.1 *General*

1. Coordinate all work at, near, or inside buildings with the Engineer. Do not work on buildings or enter buildings without prior, written authorization from the Engineer. Coordinate and obtain approval from Engineer regarding allowable working time in buildings. Obtain necessary permits and inspections. Work shall not commence until the necessary permits are issued, posted on site, and approved plans are available on site. The Design-Builder shall coordinate installation with TDOT staff at least two (2) weeks in advance of needing access to the installed cable(s)/network equipment.

2. Furnish MAC addresses in a spreadsheet for all equipment utilized as part of this project, in addition to the equipment models, serial numbers, and firmware revisions. Equipment shall be registered in the name of TDOT. Affix a MAC Address label to each device utilized. Furnish IP addresses for all equipment utilized as part of this project. Affix final IP address to each device utilized. Use labels that do not smear or fade.

3. In field equipment cabinets, fully integrate new Ethernet switches with the fiber optic termination panels. Integrate all field equipment as called for in Plans.

4. Fully integrate proposed switches with existing TMC Core switches and computer and central system hardware to form a complete local area network that allows users from TDOT TMC as shown on the Plans to access applications on application servers and the CCTV central hardware and the proposed field communication network.

5. Fully integrate upgraded LAN to accomplish/maintain L2 Field Switch, L3 Aggregation Switch, and L3 Core Switch failover and fault tolerance.

6. Fully integrate LAN equipment to provide user authentication and security functions to prevent unauthorized users and data from entering the freeway system LAN.

7. No Ethernet switch purchase, configuration, or deployment can occur until the Design-Builder's RDD has been approved in final form by the Engineer.

15.2.2 *Ethernet Bridge*

All equipment shall be installed according to the manufacturer's recommendations these specifications and the Plans.

1. Each T-1 service port shall be protected from line surges from telephone-company outside plant cables. Each bridge shall be provisioned to support streaming video over the aggregate bandwidth back to the TMC. At the TMC a central switch/router will be the primary destination for receiving all field camera video feeds over one telephone service provider multiple T-1 circuits. The Design-Builder shall be responsible for establishing the MLPPP parameters to interface with the telephone service provider T-1 circuits for communication with the TMC central system. Each communication hub shall be configured initially to accept up to four (4) T-1, with an aggregate total of 1.544 Mbps per T-1.

2. The video encoder's data port associated with the CCTV control shall each be configured to transmit at a minimum of 9600bps (or higher data rates as compatible with the CCTVs).

3. Under this contract, the Design-Builder shall be required to submit an IP addressing convention to the Engineer for approval, prior to configuring the Ethernet Bridge and video encoder addresses. The non-volatile configuration files for each Ethernet bridge, when appropriate, shall be provided electronically (CD-ROM, USB drive, or approved equal) to the Engineer as part of the as-built documentation for the system configuration.

15.2.3 *Coordination with Central System Provider / Integrator*

1. The Design-Builder shall coordinate his/her efforts with those of the TDOT's Central System Provider (SwRI's SCS platform). The Design-Builder shall accommodate the System Provider's work in every way including planning and testing support for system

integration. In general, the Design-Builder shall install and test the field equipment and accompanying communication infrastructure. The Design-Builder shall also provide software and firmware, which is not already available to the System Provider, necessary for proper operation of the equipment the Design-Builder supplies as part of this Contract. Additionally, the Design-Builder shall provide testing computers and appropriate software that shall be used to test and demonstrate proper and acceptable operation of all equipment and communications infrastructure provided and/or installed by the Design-Builder. The Design-Builder shall coordinate device locations and settings with the Provider and notify the Provider in the event any settings are changed as a result of direction from the Engineer and/or installation problems in the field.

15.4 Measurement and Payment

1. Network Switch (Type A) L2 Field Ethernet Switch will be measured in units of each and paid for at the contract price per each unit furnished, installed, and accepted. All SFP modules, optics, cabling, jumper cables, patch cables, attenuators, configuration, and testing or other labor or materials required to install and integrate the field Ethernet Switch will be considered incidental and not be paid for separately. Partial payments will be made based on the following schedule: 80% upon completion and acceptance of the standalone switch test; 20% upon completion of the channel system testing.

2. Ethernet Bridge will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing, system integration, training, documentation, and testing of a complete Ethernet Bridge including the Ethernet bridge, modules, power supply, power cable, ancillary cabling between the Ethernet bridge and the radio and/or video encoder, hardware and brackets and all incidental items to provide and install the Ethernet Bridge as intended, satisfactory completion of all testing requirements and all work, equipment and appurtenances as required for a full Ethernet Bridge installation. The price bid shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams, and other materials necessary to document the operation of the Ethernet Bridge. This price shall be full compensation for all labor, tools, materials, equipment, and incidentals necessary to complete the work.

3. Network Configuration Update will be paid for and measured as lump sum. LAN integration includes configuration and integration of all LAN hardware, firmware, and software to complete the LAN architecture, and submittal of the RDD. Integration of Design-Builder-provided network equipment with the existing TDOT firewall and integration of Internet based software applications with TDOT's existing Internet connection infrastructure shall be incidental and not paid for separately. All cabling, hardware, accessories, labor, and materials not provided with TDOT furnished network equipment required to make the unit function as part of this project shall be considered incidental and not paid for separately. Coordinating/updating/configuring TDOT's existing LAN

Network Management and Remote Monitoring Software (NMS) shall be included as part of the LAN integration and not paid for separately. Partial payments for this item will be made on the following schedule: 30% upon completion and acceptance of the RDD; 30% upon installation, integration and acceptance of LAN equipment at L3 Aggregation Switch locations including integration with the TMC Core Switches, 10% upon acceptance of the NMS configuration updates, and 30% upon installation, integration and acceptance of the entire project furnishing of and acceptance of network as-built documentation.

4. Payment for all cabling, jumpers, adapters, sockets, LAN patch panels, wall outlets, and other hardware shall be considered incidental and no separate payment will be made. Payment will be made under:

Item No.	**Description**	**Unit**
725-21.11	NETWORK SWITCH (TYPE A)	EACH
725-21.14	NETWORK CONFIGURATION	LS
725-21.16	ETHERNET BRIDGE (FIELD)	EACH
725-XX	ETHERNET BRIDGE (TMC)	EACH

L2 Field Ethernet Switch and Ethernet Bridge will be paid per each as follows:

1. 50% of the contract unit price upon completion Bench Test Component, Bench Test System, Pre-installation test results.

2. 20% of the contract unit price upon completion of Stand Alone Testing at the demarcation cabinet.

3. 20% of the contract unit price upon Conditional System Acceptance test results.

4. Final 10% of the contract unit price upon Final System Acceptance.

Network Configuration Update will be paid on a lump sum basis as follows:

5. 100% of the contract unit price upon Conditional System Acceptance.